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Schwartz

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[54] **MUSIC SIGNAL CONVERSION APPARATUS**

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[51] **Int. Cl.²** **G10H 1/04**

[58] **Field of Search** 84/1.01, 1.11, 1.12, 84/1.19, 1.24, 1.27

[56] **References Cited**

UNITED STATES PATENTS

3,535,431	10/1970	Szabo	84/1.11
3,629,484	12/1971	Suzuki	84/1.11
3,762,265	10/1973	Adachi	84/1.01

OTHER PUBLICATIONS

Experimenting with Electronic Music by Robert Brown & Mark Olson, pp. 95–100.

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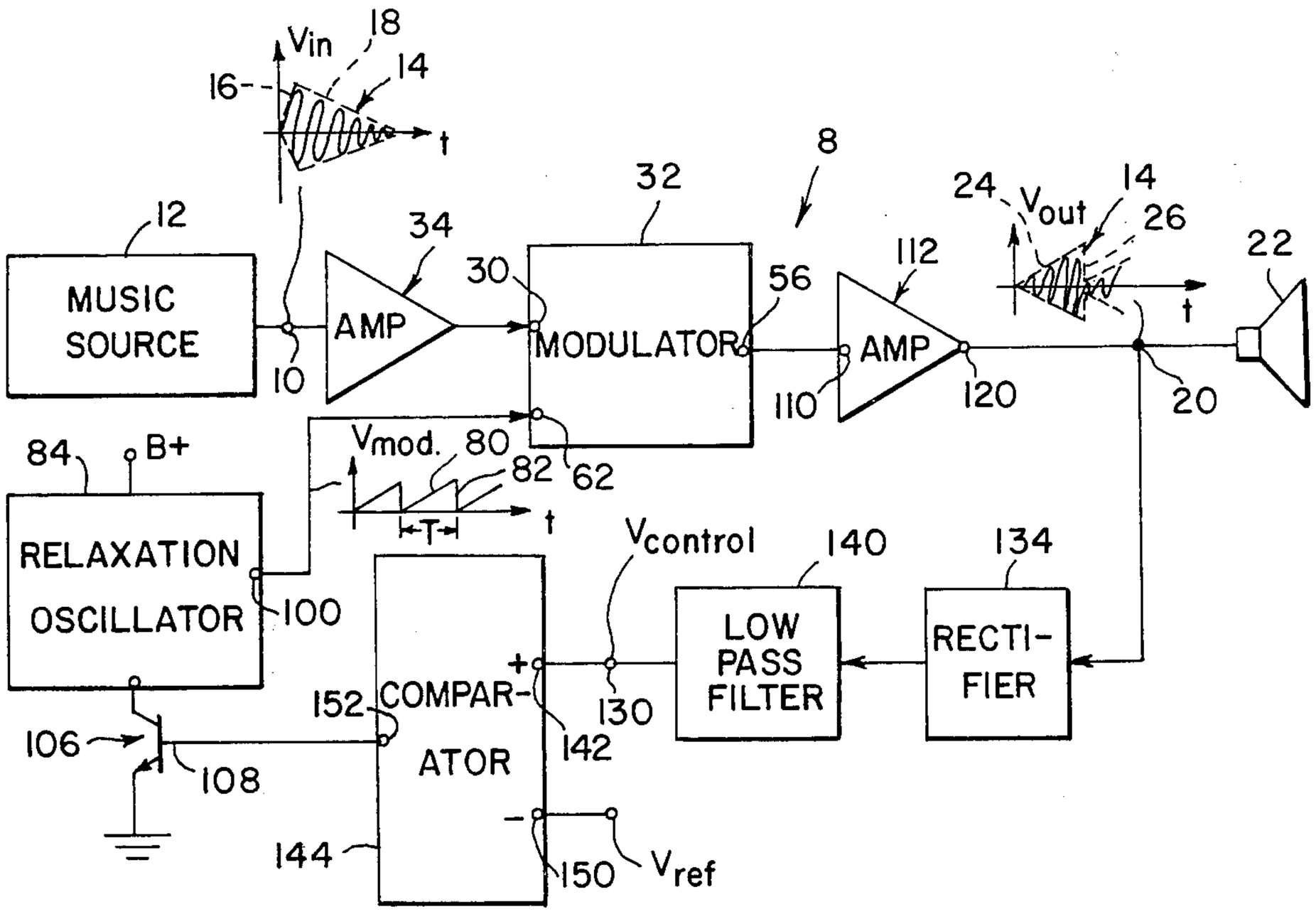
Attorney, Agent, or Firm—Jack D. Slobod

[57] **ABSTRACT**

Apparatus for converting the relatively rapid rise time, relatively long fall time tone envelopes of a music source output to envelopes having relatively long rise time and relatively rapid fall time includes a sawtooth relaxation oscillator whose output feeds a modulator which is also fed by the music source. The oscillator is turned on via a transistor switch when the average power of the signal at the output of the modulator exceeds a predetermined reference threshold signal.

1 Claim, 2 Drawing Figures



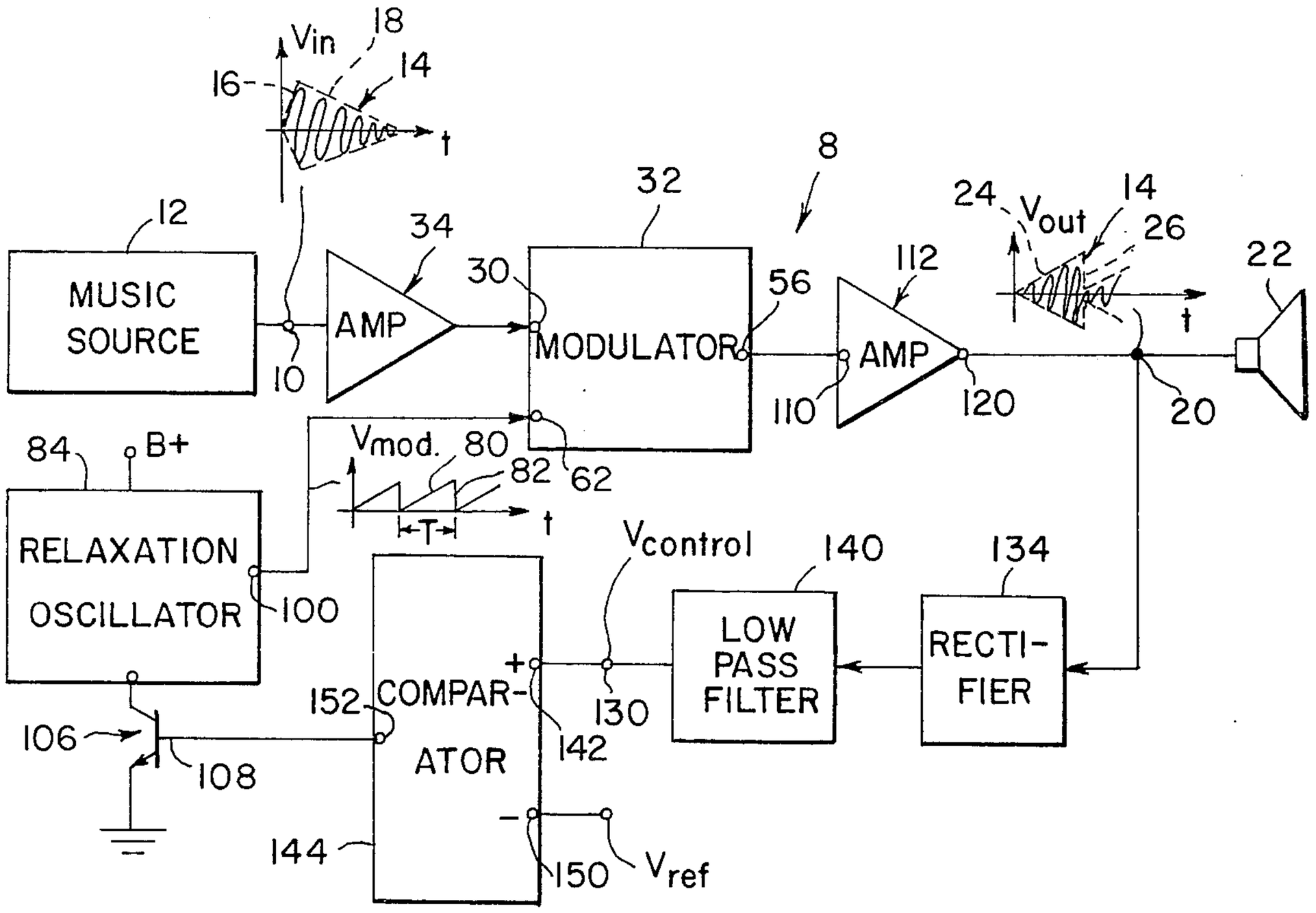

Vin
18
14
16
t
12
MUSIC SOURCE
10
34
AMP
32
30
8
MODULATOR
56
112
AMP
110
120
24
Vout
14
26
t
22
20
84
B+
Vmod.
80
82
62
T
t
RELAXATION OSCILLATOR
100
106
108
Vcontrol
140
134
LOW PASS FILTER
RECTI-FIER
152
COMPAR-ATOR
+
130
142
144
150
Vref

Fig. 1

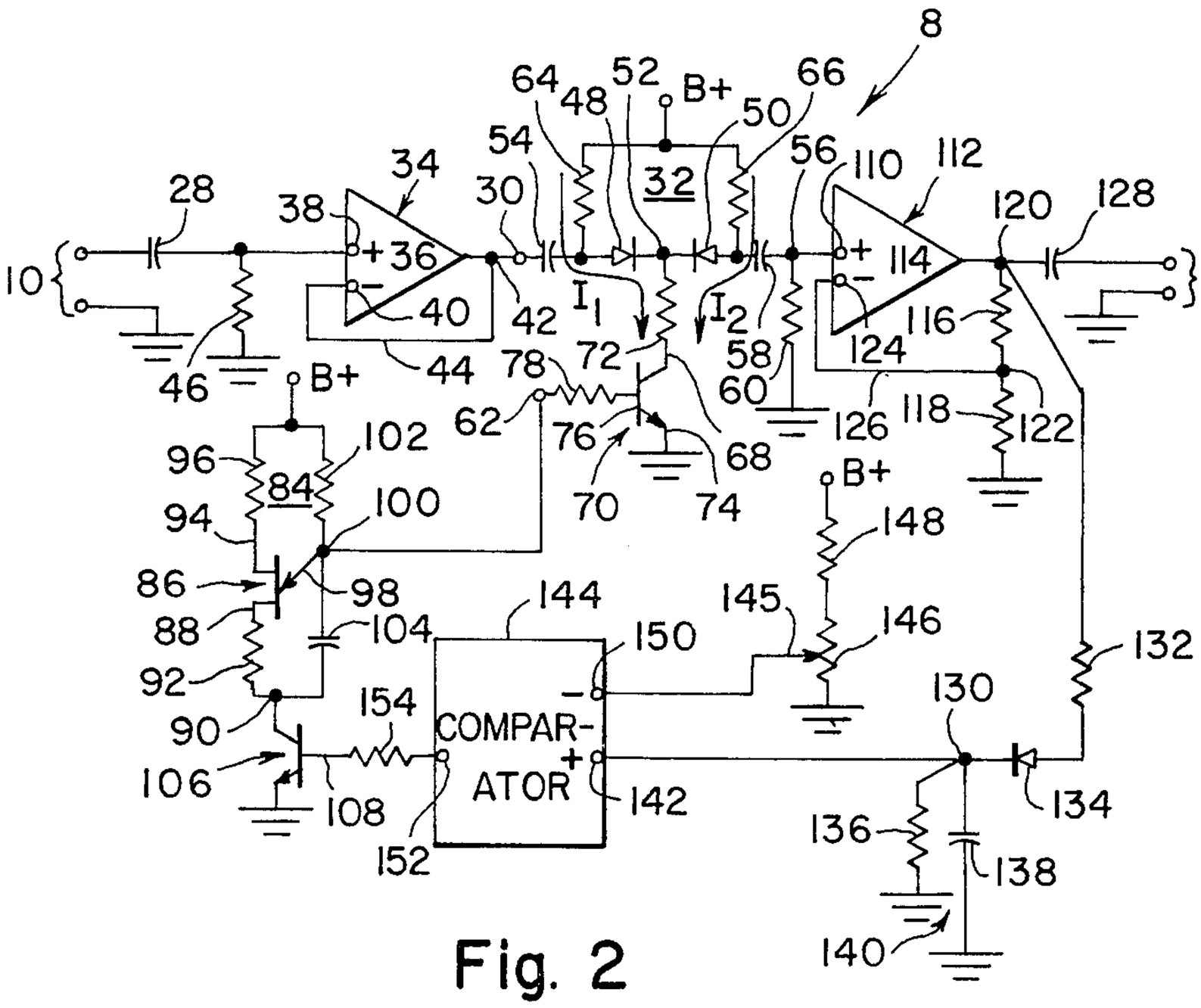

8
64
48
52
B+
66
54
56
110
112
34
30
32
28
38
36
120
128
10
40
42
I1
I2
114
20
46
44
78
72
58
60
116
124
B+
62
76
68
126
118
122
102
96
84
100
70
74
B+
148
94
86
98
144
145
146
104
150
132
88
92
154
COMPAR-
ATOR
130
90
106
108
142
134
136
138
152
140

Fig. 2

MUSIC SIGNAL CONVERSION APPARATUS

FIELD OF THE INVENTION

The present invention relates generally to apparatus for modifying a music signal for producing unusual effects. In its particular aspects, the present invention relates to a device for modulating a music signal with a sawtooth signal to produce an effect as if each individual tone signal thereof were played backwards.

BACKGROUND OF THE INVENTION

A musical note or tone produced by a musical instrument of string, piano or percussion types is characterized by an envelope having a relatively rapid rise time and a relatively slow, usually exponential, fall or decay time. If an isolated musical note signal of the aforementioned type were recorded, as with a tape recorder, and then played backwards, there would result a highly unusual and pleasing note signal having a slow rise and a rapid decay. Of course, however, music is composed of a sequence of notes and playing a prerecorded musical program backwards would yield the sequence of notes in backwards order.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide apparatus for converting relatively rapid rise time, relatively slow fall time envelopes of musical note signals to envelopes having a relatively slow rise time and a relatively rapid fall time.

It is a further object of the present invention to provide apparatus for modulating a music signal with a sawtooth signal when the music signal power exceeds, on average, a predetermined threshold.

SUMMARY OF THE INVENTION

Briefly, the aforementioned and other objects of the present invention are satisfied by providing an apparatus having an input port for coupling to a source of music signal. The input port feeds one input terminal of a modulator. The other modulator input terminal is fed by the output of a sawtooth relaxation oscillator. The sawtooth output signal of the oscillator has a relatively slow rise time and relatively rapid fall time and while the envelope of each individual note signal from the music source has opposite rise and fall characteristics to the sawtooth signal, the result of the effective multiplication of the sawtooth and input music signal in the modulator creates note signals at the modulator output having slow rise time and rapid fall time. Consequently, each individual note signal from the music source is modified as if it were individually recorded and played back in time reversed form. However, the sequence of the note signals is unchanged.

If the sawtooth signal were continuously applied to the modulator even when the music signal were of relatively low amplitude, there would result undesirable switching noise introduced by the sawtooth signal. To avoid this noise, the sawtooth signal is applied to the modulator only when the music signal power exceeds a predetermined threshold. This is accomplished by utilizing rectifying and low pass filtering means coupled to the output of the modulator for producing a unidirectional control signal indicative of the average power in the output music signal. This control signal is compared with a predetermined D.C. reference signal in a comparator. The sawtooth oscillator includes a transistor switch positioned for applying power supply voltage to the oscillator. The transistor switch is controlled from the output of the comparator for turning on the sawtooth oscillator when the control signal exceeds the reference signal.

Other objects, features and advantages of the present invention will become apparent upon perusal of the following detailed description of the preferred embodiment of the present invention when taken in conjunction with the appended drawing wherein:

FIG. **1** is a block diagram for the music signal conversion apparatus of the present invention; and

FIG. **2** is a detailed schematic diagram corresponding to the block diagram in FIG. **1**.

DETAILED DESCRIPTION

Referring to FIGS. **1** and **2** of the drawing, the music signal conversion apparatus **8** of the present invention includes an input port **10** adapted to be coupled to a music source **12.** Source **12** provides a music input signal V_{in} including note signals **14** as produced by musical instruments of the string, piano or percussion types. Note signals **14** are A.C. signals having envelopes characterized by a relatively rapid rising portion **16** and a relatively slow falling portion **18.**

Apparatus **8** further has an output port **20** adapted to drive a speaker **22** with an output music signal V_{out} in which the note signals **14** are modified to have an envelope including a relatively slow rising portion **24** and a relatively rapid falling portion **26.** Consequently, each individual note signal **14** at output port **20** appears to be time reversed from the note signal **14** at input port **10.** The manner in which this unusual effect is accomplished will become apparent as the discussion proceeds.

Preferably, the input port **10** is A.C. coupled via a capacitor **28** to an input terminal **30** of a modulator **32.** A buffer amplifier **34** is interposed between capacitor **28** and input terminal **30.** Buffer amplifier **34** is mechanized using a differential amplifier **36.** Capacitor **28** is connected to a positive input terminal **38** of amplifier **36** while the negative input terminal **40** and output terminal **42** thereof are interconnected by a feedback lead **44** to provide buffer amplifier **34** with a unity gain. A resistor **46** is connected between amplifier input terminal **38** and ground to provide an input impedance at input port **10** matching the output impedance of source **12.**

Amplifier output terminal **42** is connected to modulator input terminal **30.** Modulator **32** is synthesized utilizing a pair of oppositely directed series diodes **48** and **50.** The cathodes of diodes **48** and **50** are joined at a node **52.** Modulator input terminal **30** is connected to the anode of diode **48** via a capacitor **54.** An output terminal **56** of the modulator is connected to the anode of diode **50** via a capacitor **58** and a resistor **60** is connected between output terminal **56** and ground. The resistance of the series diodes **48, 50** form an A.C. voltage divider along with resistor **60.** The resistances of diodes **48** and **50** are varied in correspondence to the instantaneous value of a sawtooth modulating signal V_{mod} at a second input terminal **62** of modulator **32.**

To accomplish this, a pair of resistors **64** and **66** are respectively connected between the positive supply voltage, B+, and the anodes of the respective diodes **48** and **50.** Further, the node **52,** between diodes **48** and **50** is coupled to the collector electrode **68** of an NPN transistor **70** via a resistor **72.** The emitter electrode **74**

of transistor **70** is grounded while its base electrode **76** is connected to the modulation input terminal **62** via a resistor **78.**

The resistors **64, 66** and **72** are chosen for operation of the diodes **48** and **50** at relatively low current levels for varying the resistance of currents I_1 and I_2. Bias current I_1 flows through resistor **64,** diode **48** and transistor **70** while bias current I_2 flows through resistor **66,** diode **50** and transistor **70.** These bias currents are increased in response to increasing signal at modulator input terminal **62** for decreasing the resistances of the diodes **48** and **50** and thereby increasing the fractional A.C. gain associated with the voltage divider formed by the diodes and resistor **60.**

The modulating signal V_{mod} is generally in sawtooth form composed of relatively slowly rising portions **80** and relatively rapidly falling portions **82.** The period **80** and relatively rapidly falling portions **82.** The period T associated with V_{mod} is chosen slightly longer than the duration of the note signals **14,** on the order of a second. The modulator **32** effectively multiplies V_{in} and V_{mod} to produce V_{out}.

V_{mod} is produced by a relaxation oscillator **84** having an output terminal **100** coupled to the modulator input terminal **62.** Oscillator **84** includes a unijunction transistor **86** whose first base electrode **88** is connected to a node **90** through a small current limiting resistor **92,** such as 10 ohms. The second base electrode **94** of unijunction transistor **86** is connected to B+ via a resistor **96.** The emitter electrode **98** of unijunction transistor **86** is directly connected to the output terminal **100** of oscillator **84.** A resistor **102** is connected between B+ and terminal **100** while a capacitor **104** is connected between terminal **100** and node **90.** Node **90** is connected to ground via an NPN transistor switch **106** for selectively enabling power supply voltage to be applied across oscillator **84.**

When transistor switch **106** is rendered conductive by a suitably positive signal at its base electrode **108,** the oscillator **84** is turned on. The oscillator **84** operates by capacitor **104** being charged through resistor **102,** creating the slowly rising portion **80** of V_{mod}, until a suitable voltage is present on the capacitor for causing conduction between emitter electrode **98** and base electrode **88.** At this point the capacitor **104** is rapidly discharged via the unijunction transistor **86,** creating the rapidly falling portion **82** of V_{mod}.

The output terminal **56** of modulator **32** is coupled to the input terminal **110** of an amplifier **112** for providing suitable amplification and buffering for driving speaker **22.** Amplifier **112** is formed by an operational amplifier **114** whose positive input terminal is the amplifier input **110.** A voltage divider composed of series resistors **116** and **118** is connected between the operational amplifier output terminal **120** and ground. The junction **122** between resistors **116** and **118** is connected to the amplifier negative input terminal **124** by a lead **126.** As a result of this feedback configuration, the amplifier **112** is provided with a positive gain greater than unity. The amplifier output terminal **120** is A.C. coupled to output port **20** via a capacitor **128.**

If the input music signal V_{in} were continually modulated with the sawtooth V_{mod} an undesirable switching noise would be apparent in V_{out} when V_{in} and V_{out} are relatively low levels. To obviate this switching noise, V_{mod} is applied to modulator **32** only when V_{out} is greater than a predetermined power level. This is accomplished by actuating the transistor switch **106,** to turn on oscillator **84** only when V_{out} is greater than a predetermined threshold power level.

A unidirectional positive signal $V_{control}$ at point **130** is derived to have a value indicative of the power level of V_{out}. Point **130** is connected to amplifier output terminal via the series combination of a resistor **132** and a rectifier diode **134** to produce a positive unidirectional signal. The parallel combination of a resistor **136** and capacitor **138** are applied between point **130** and ground to form a low pass filter **140** having a time contant, on the order of several seconds. As a result, the signal $V_{control}$ is a slowly varying D.C. signal indicative of the power level of V_{out}. Point **130** is connected to the positive input terminal **142** of a comparator **144.**

An adjustable reference voltage V_{ref} is provided at the wiper **145** of a potentiometer **146** which is connected in series with a resistor **148** across the supply voltage B+. Wiper **145** is connected to the negative input terminal **150** of comparator **144.** The comparator is of the type having a zero voltage on its output terminal **152** whenever the voltage at its positive input terminal **142** is less than the voltage at negative input terminal **150.** When the voltage at the positive input terminal **142** exceeds the voltage at negative input terminal **150** a positive voltage appears on output terminal **152.**

Output terminal **152** is coupled to the base electrode **108** of transistor switch **106** via a resistor **154.** As a result, the transistor switch **106** is activated when $V_{control}$ exceeds V_{ref}.

While the preferred embodiment of the present invention has been described and illustrated in particular detail, it should be noted that numerous modifications, additions and omissions in the details thereof are possible within the intended spirit and scope of the invention claimed herein.

What is claimed is:

1. Apparatus for converting an input music signal composed of sequential note signal envelopes having a relatively rapid rise time and a relatively slow fall time to an output music signal whose sequential note signal envelopes have a relatively slow rise time and a relatively rapid fall time, said apparatus comprising: an input port adapted to be coupled to a source for said input music signal; a relaxation oscillator means for producing an output signal composed of periodic signal elements of generally sawtooth shape in response to the application of electrical power to said oscillator means; each said signal element having an amplitude which increases with time; modulator means having a first input terminal coupled to said input port and having a second input terminal fed by said oscillator means; said modulator means having an output terminal coupled to said output port; electrically actuatable switch means positioned for selectively applying electrical power to said oscillator means; rectifying and low pass filtering means fed from said output port and having an output control signal indicative of the average value of output signal power at said output port; means for comparing said control signal with a predetermined reference signal; said comparing means being coupled to said switch means and being configured for actuating said switch means when said control signal exceeds said predetermined reference signal.

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